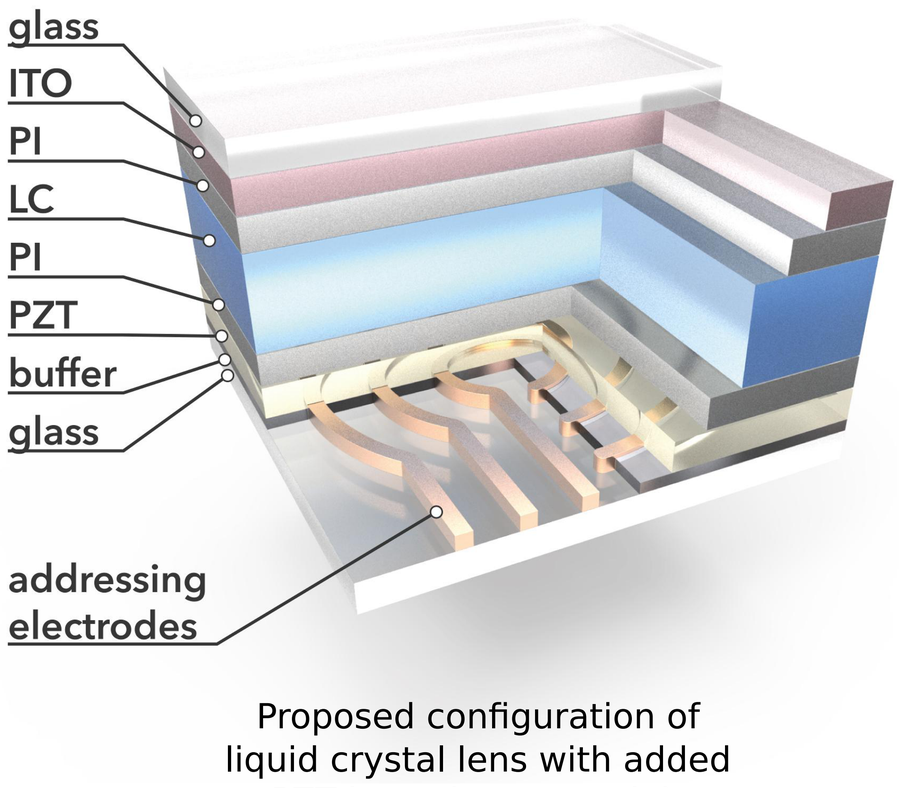
High dielectric constant materials for low power liquid crystal tunable lenses

O. Willekens[1], J. P. George1, K. Neyts1, J. Beeckman[1]
[1]*Liquid Crystals and Photonics Group, Ghent University, Belgium*
oliver.willekens@elis.ugent.be

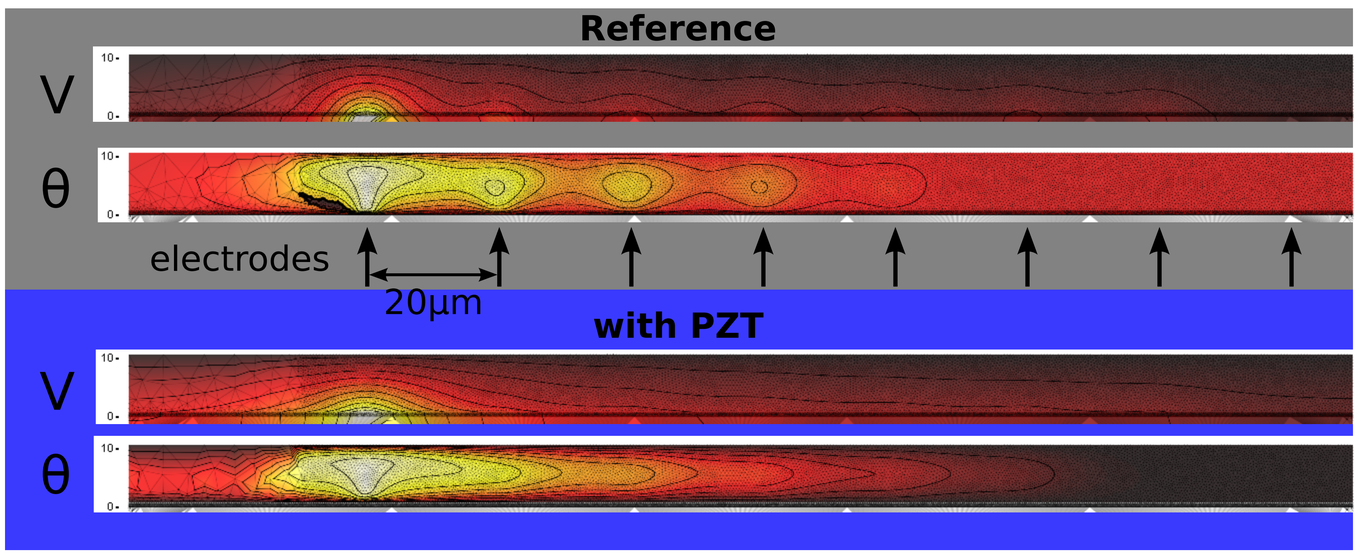
ABSTRACT

We have demonstrated the advantageous effect of adding a layer of **lead zirconate titanate (PZT)** to a **vertical field switching (VFS) liquid crystal lens**. Simulations show that because of the high dielectric constant of PZT, the voltage profile and hence the director tilt become more smoothly varying, similar to the effect of a potential divider. We fabricated a tunable focal length liquid crystal lens with PZT and compared its performance to that of one without the PZT layer.



Proposed configuration of liquid crystal lens with added PZT layer (not to scale).

SIMULATION

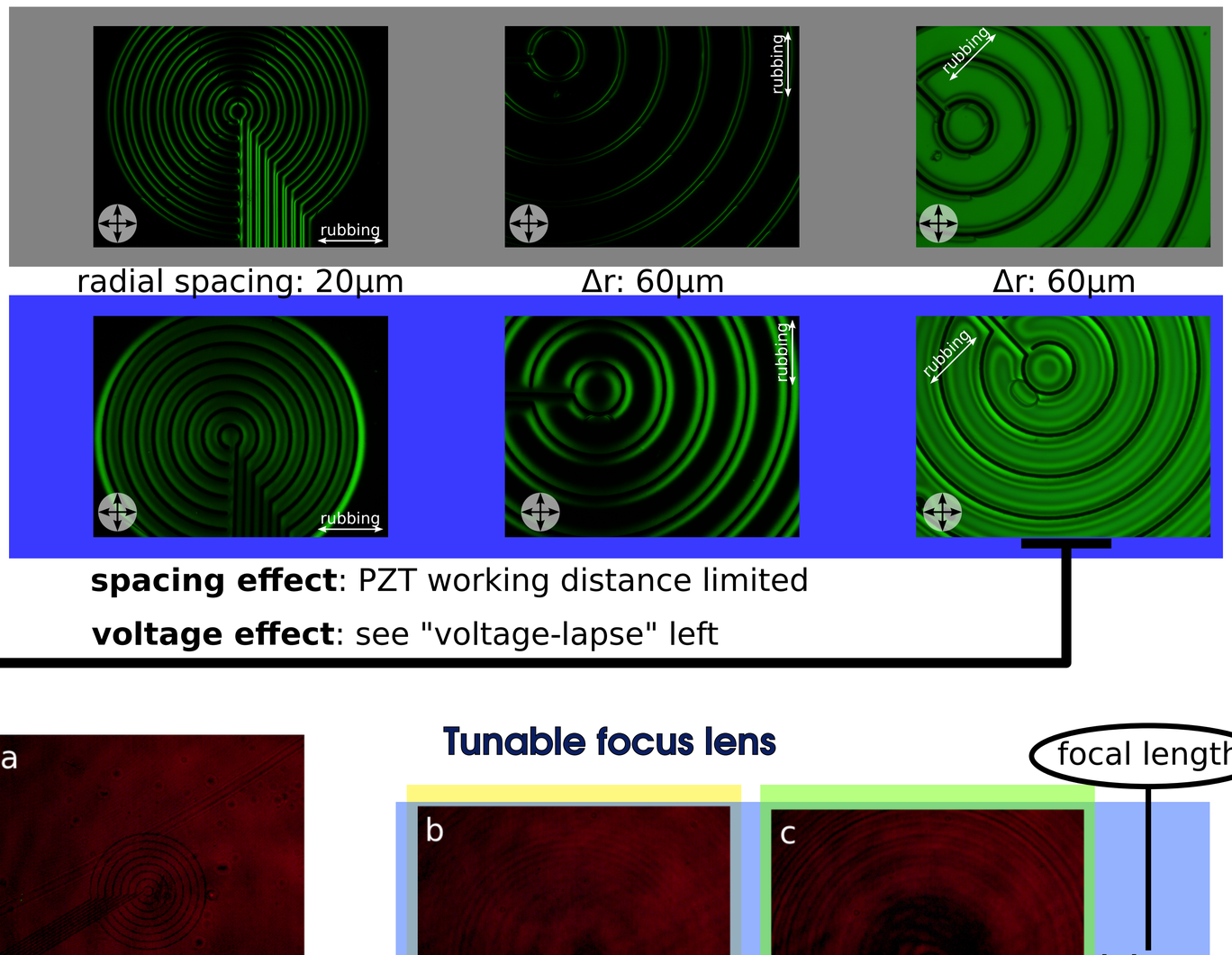


By adding a 1µm thick PZT layer (ε = 500) over the 3µm wide electrodes, spaced 20µm apart, the isopotential lines become more smooth. This in turn leads to a tremendous improvement in the tilt, θ, of the liquid crystal director.

EXPERIMENTAL CHARACTERIZATION

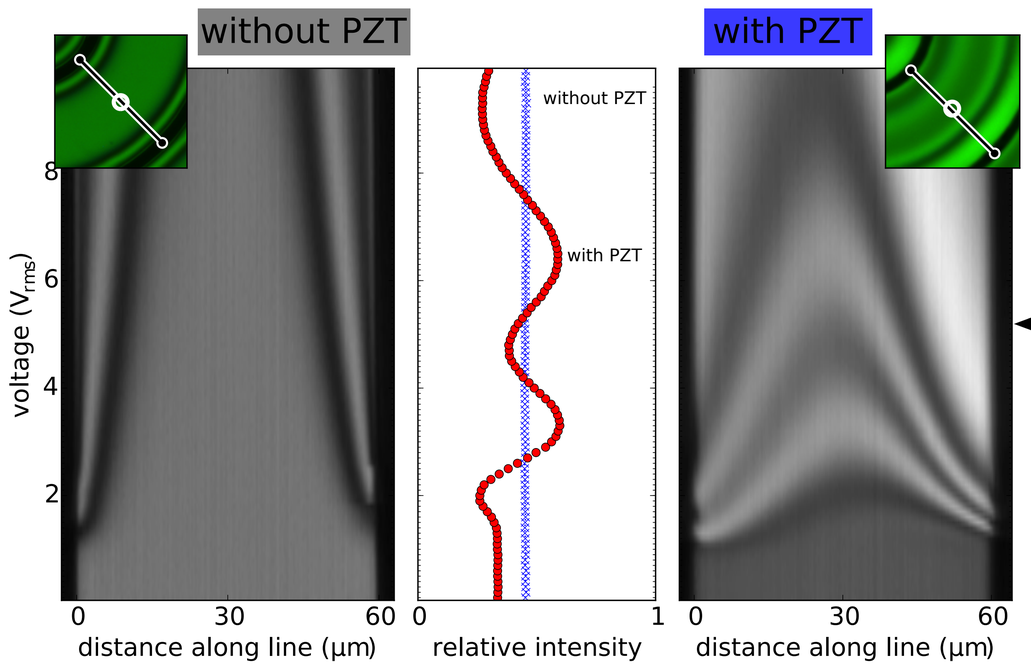
Polarizing Optical Microscope

$$I \propto \sin^2\left(\tfrac{\pi}{\lambda}(n_{eff}(V) - n_{ord})d\right)$$



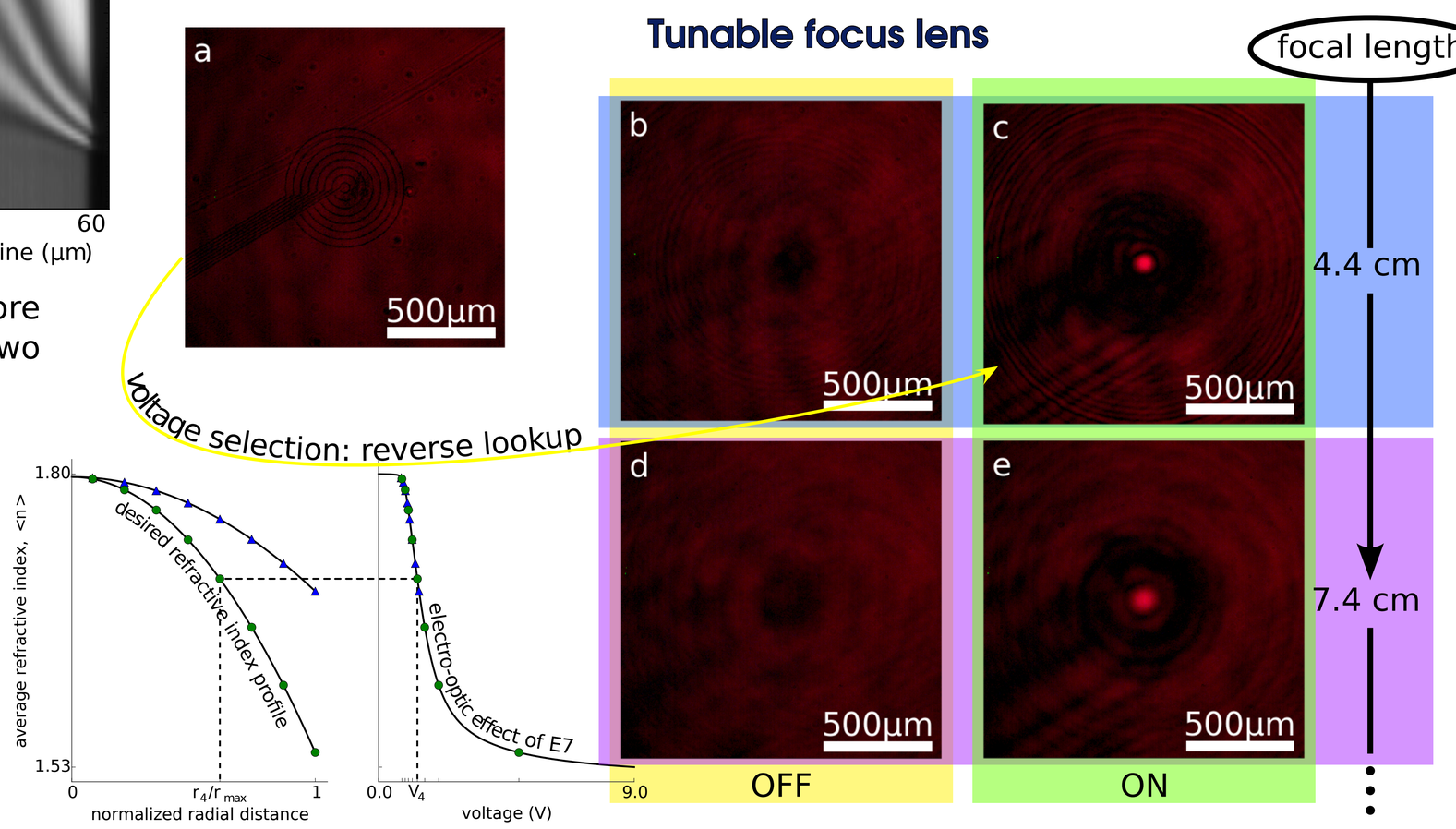
spacing effect: PZT working distance limited

voltage effect: see "voltage-lapse" left



PZT bridges the gap: the electric field is more spread, so that even halfway between two electrodes, the molecules tilt upwards.

Tunable focus lens



References:

GEORGE, J. P., et al. Lanthanide-Assisted Deposition of Strongly Electro-optic PZT Thin Films on Silicon: Toward Integrated Active Nanophotonic Devices. *ACS applied materials & interfaces*, 2015, 7.24: 13350-13359.

JAMES, Richard, et al. Finite-element modeling of liquid-crystal hydrodynamics with a variable degree of order. *Electron Devices, IEEE Transactions on*, 2006, 53.7: 1575-1582.